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**NASA TECHNICAL  
MEMORANDUM**

NASA TM X- 72015

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(NASA-TM-X-72015) A TECHNIQUE FOR  
DISPLAYING FLIGHT INFORMATION IN THE  
FIELD OF VIEW OF BINOCULARS FOR USE BY  
THE PILOTS OF RADIO CONTROLLED MODELS  
(NASA) 17 p HC \$3.25

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**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
LANGLEY RESEARCH CENTER, HAMPTON, VIRGINIA 23665**

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A TECHNIQUE FOR PRESENTING FLIGHT INFORMATION  
IN THE FIELD OF VIEW OF BINOCULARS FOR USE  
BY THE PILOTS OF RADIO CONTROLLED MODELS

SUMMARY

A display system has been developed to provide flight information to the ground based pilots of radio controlled models used in flight research programs. The display system utilizes data received by telemetry from the model, and presents the numerical information in the field of view of the binoculars used by the pilots. In the system developed for the Langley Spin/Stall Research Program, where control of the model is shared between two pilots, angle of attack and true airspeed are displayed for one of the pilots and angle of sideslip and an on/off control system status signal are displayed for the other pilot.

INTRODUCTION

In the NASA - Langley Spin/Stall Research Program, unpowered aircraft models (typically a 1/10 scale model of a military fighter plane) are released from a helicopter at an altitude of about 1525 meters (5000 feet). Two pilots seated on converted gun turrets exercise control over the model via a radio link while viewing it through binoculars trained on it by the turret operator. The model is usually put into a dive until it attains a desired airspeed, at which time it is maneuvered into a stall/spin condition. The tests are de-

signed to evaluate spin recovery techniques and the effectiveness of spin prevention techniques. A parachute is deployed to recover the model. The entire sequence typically lasts 20 to 30 seconds.

Since the field of view of a pilot is limited by the binoculars, the perspective is also limited, making it difficult to accurately judge the attitude and airspeed of a model. The Binocular Information Display system (BID), was conceived and developed to provide the information needed by the pilots for better and more precise control of the models undergoing tests.

#### SYSTEM DESCRIPTION

The data presented to the pilot in numerical form are developed from telemetered in-flight measurements. The sensor is a miniature flow direction-velocity sensor (Figure 1), mounted on a nose boom. The body of the sensor pivots through two axes and the vanes align it with the airstream. Potentiometers are used to sense both the aircraft angle of attack and angle of sideslip. A "propeller" driven by the air provides a signal proportional to true airspeed.

Figure 2 shows a block diagram of the entire display system. In the model, the sensors are connected to individual voltage controlled oscillators (VCO) and the measurement is telemetered to the ground using standard FM/FM telemetry techniques. In addition, an on/off control system status signal is transmitted, typically to indicate the status of the automatic spin prevention system. The data are received on the ground, the FM signals discriminated and the resultant analog signals are converted to Binary Coded Decimal (BCD). The information

is then routed to sets of seven segment incandescent readouts through BCD-to-seven-segment decoders.

The optical system, including the incandescent readout, is mounted on the underside of one barrel of the binoculars (Figure 3). A system of lenses and mirrors is used to bring the image of the readout to the pilot's eye. The image is focused at infinity and a pilot sees the information above his view of the model in the binocular as shown schematically in Figure 4.

The two pilots are seated on converted gun turrets (see Figure 5), with a tracker who controls the turret. Normally, angle of attack and velocity are displayed for one pilot; while, angle of sideslip and a status signal are displayed for the other.

Electronics - Figure 6 is a schematic diagram of the ground-based electronics. The discriminators are rack mounted in an instrumentation trailer and the electronics for each pilot's display is located on the tracking trailer. The discriminators and the VCO's in the model use the standard Inter-Range Instrumentation Group (IRIG) frequency channels. Table 1 lists the measured quantities and the IRIG channels assigned for use with the display in the spin/stall program. The system can be adapted to display any information that can be handled by an IRIG channel, or supplied to the Binocular Information Display as a d.c. voltage.

Each analog-to-digital converter (ADC) accepts a  $\pm 10$  volts input and provides a nine-bit BCD output that is decoded to yield a three-digit output ranging from -199 to +199. The airspeed input signal ranges from 0 to +10 volts for 0 to 199 MPH so the polarity indication is not required (airspeed is displayed in miles per hour).

In each of the two angle channels, a two-digit readout plus a polarity indicator are provided, permitting the pilots to read positive and negative angles of attack and right or left sideslip. In the control status indicator channel, a relay energized by the discriminator directly controls the readout to indicate ON or OFF.

A DPDT switch is provided to permit the pilots to interchange the angle of attack and angle of sideslip displays. A pushbutton lamp test switch was also provided that tests all segments of each display. Power supplies are built into the electronic boxes to permit the system to operate from 115 Vac. Special multi-conductor cables terminated with subminiature connectors were used between the electronic boxes and the optical systems to minimize the overall size of the packages attached to the binoculars.

Optical System - Figure 7 shows schematically the optical arrangement. A system of lenses and mirrors brings the image of the readouts to a beam splitter mounted in front of one barrel of the binoculars. The total length of the optical path, from the readouts to the objective lens of the binoculars, was kept to 305 mm (12 inches) and the path was folded so that all elements of the system could be boxed compactly under one barrel of the binoculars.

Since each pilot has a display attached to one barrel of his binoculars and the other barrel free, the beam splitter causes some difference in brightness of external light; but it is small and not objectionable to the pilots.

Because the readouts are relatively large and their images are magnified by the binoculars, the optical system reduces the size of the images presented

to the binoculars. The binoculars are 7 power magnification and have 50 mm diameter objective lenses. They subtend an angle of eight degrees, and to be most acceptable to the pilots, it was concluded that the numbers should occupy about one quarter of the field of view or about two degrees.

Since the readouts are 7.82 mm high and the optical path is 305 mm long, the readouts subtend an angle,  $\theta$ , of  $1.47^\circ$ . When this angle is magnified seven times by the binoculars it becomes 10.3 degrees. A three element reducing or negative lens is used to reduce the angle to approximately two degrees. Each element of the lens has a focal length of -33 mm and a diameter of 25 mm.

Referring to Figure 7, it can be seen that the image formed by the negative lens becomes the object of the collimating lens. The collimating lens focuses the image at infinity so that the pilot can shift his gaze from the model to the readout images and vice versa without refocusing his eyes. The collimating lens has a focal length of 132 mm and a diameter of 31.8 mm.

The brightness of the readouts was adjusted to compensate for losses in the optical system and to provide good contrast against a bright cloud background. The interior of the optical box is coated with flat black paint to optimize contrast and to minimize reflections. The incandescent readouts selected have a typical brightness of 8000 relative foot lamberts at their normal 4-volt operating level. Rated life at this voltage is 200,000 hours mean time before the first filament failure. The brightness was approximately doubled by raising the voltage to 5 volts, but the expected life of the readout filament was reduced to approximately 13,750 hours as estimated by the formula:

$$\text{Rated Life} = \left[ \frac{V_0}{V} \right]^{12} L_0$$



where  $V_0$  is the design voltage,  $V$  is the applied voltage and  $L_0$  is the life expectancy at the design voltage. Experimentally, a readout was operated at 6.5 volts for 1500 hours before one of the seven segments failed. This test indicated better than expected reliability and a satisfactory operating life at the 5-volt level.

Operational Characteristics - Although the display can indicate angles of attack and sideslip up to  $\pm 99$  degrees, the flow direction sensor on the model limits angle of sideslip to  $\pm 60$  degrees. The maximum airspeed that can be indicated is 199 MPH since a nine-bit BCD ADC is used. The nine-bit BCD outputs were selected over thirteen-bit BCD outputs principally because of the lower susceptibility to noise, i.e., each output unit corresponds to 50 mv at the ADC input while in thirteen-bit ADC's each output unit would correspond to 5 mv. These full scale ranges are sufficient for most of the spin/stall model programs. It is anticipated that the ADC in the airspeed channel would be changed to a thirteen-bit package if a higher-speed model is to be flown.

Some of the model maneuvers during a typical flight are quite rapid, and the angle signals in particular are noisy because the flow-direction sensing device has low damping. Hence, signal smoothing is used to minimize pilot confusion due to rapid changes of the indicator. Taped flight data from prior flights was used to optimize the time constant of filters to 0.78 seconds in the output stage of the discriminators. Normally, the least significant digit is one, so that the airspeed indicator changes one count when the airspeed changes one mile per hour, and each angle indicator changes one count for a one degree change in angle. However, when additional data smoothing is desired,

the change in the angle indicators can be made to occur each two degrees or each five degrees by interchanging a small plug-in circuit board.

Errors in the displayed information are principally due to inaccuracies in the sensor and the data transmission system, and are typically less than  $\pm 3$  percent of sensor full scale. This value assumes that the normal resolution of the angle readouts is being used--one count change for each degree. Accuracy of the display system alone--the discriminators through the readouts--is one count,  $\pm 1/2\%$  of full scale.

Concluding Remarks - The display system has been installed on the drop model tracker. Field tests completed to date have shown the image size, clarity and brightness to be satisfactory and the system has been accepted for operational service.

MEASURED QUANTITY	IRIG CHANNEL	FREQUENCY & DEVIATION
ANGLE OF ATTACK	7	2.3 kHz $\pm$ 7-1/2%
SIDESLIP ANGLE	8	3.0 kHz $\pm$ 7-1/2%
VELOCITY	9	3.9 kHz $\pm$ 7-1/2%
ELECTRONICS STATUS	13	14.5 kHz $\pm$ 7-1/2%

Table I - Telemetry Channels and Frequencies

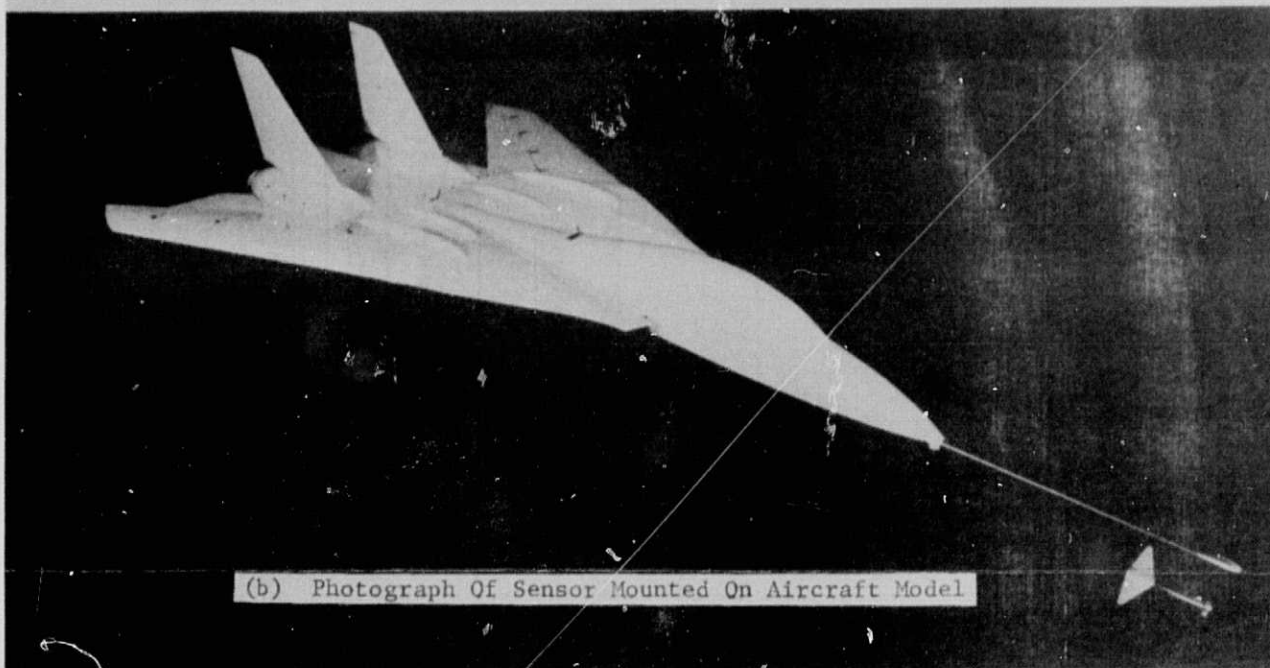
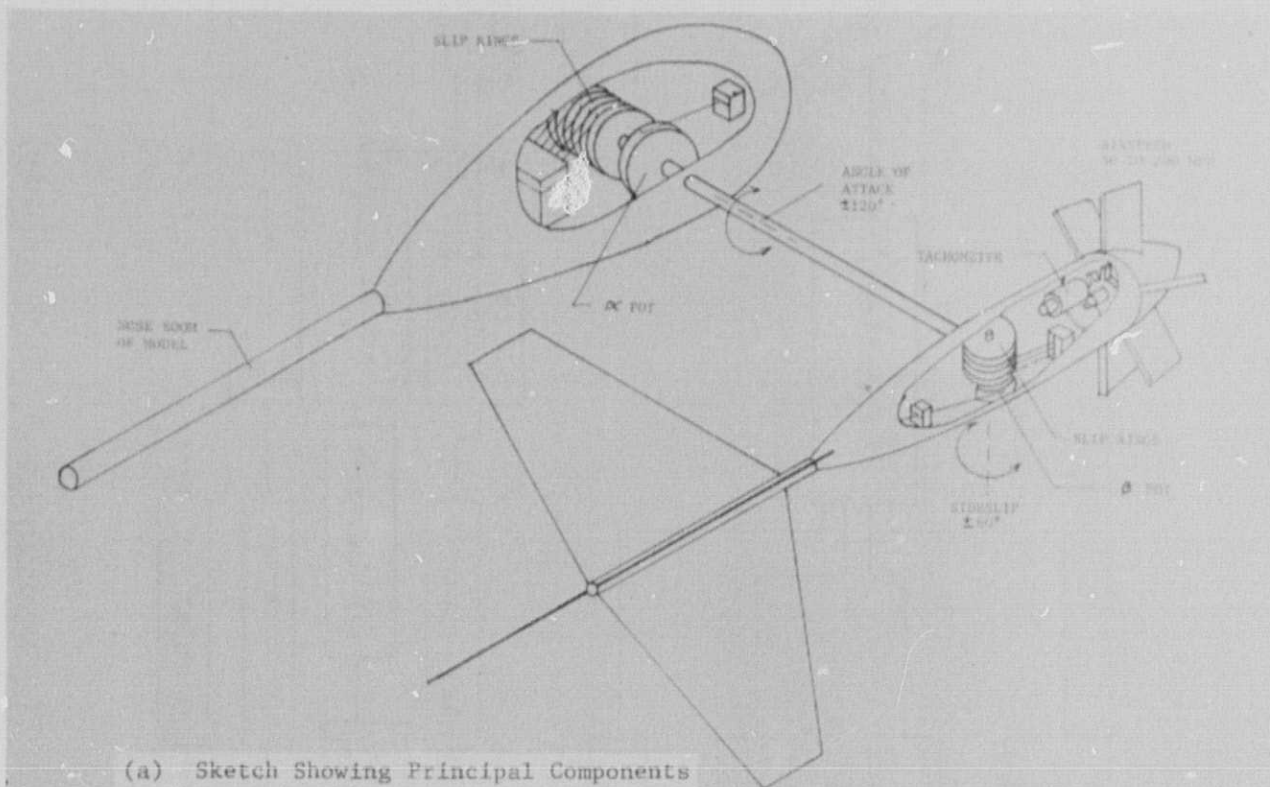


Figure 1 - Miniature Flow Direction - Velocity Sensor, Model FDV-5

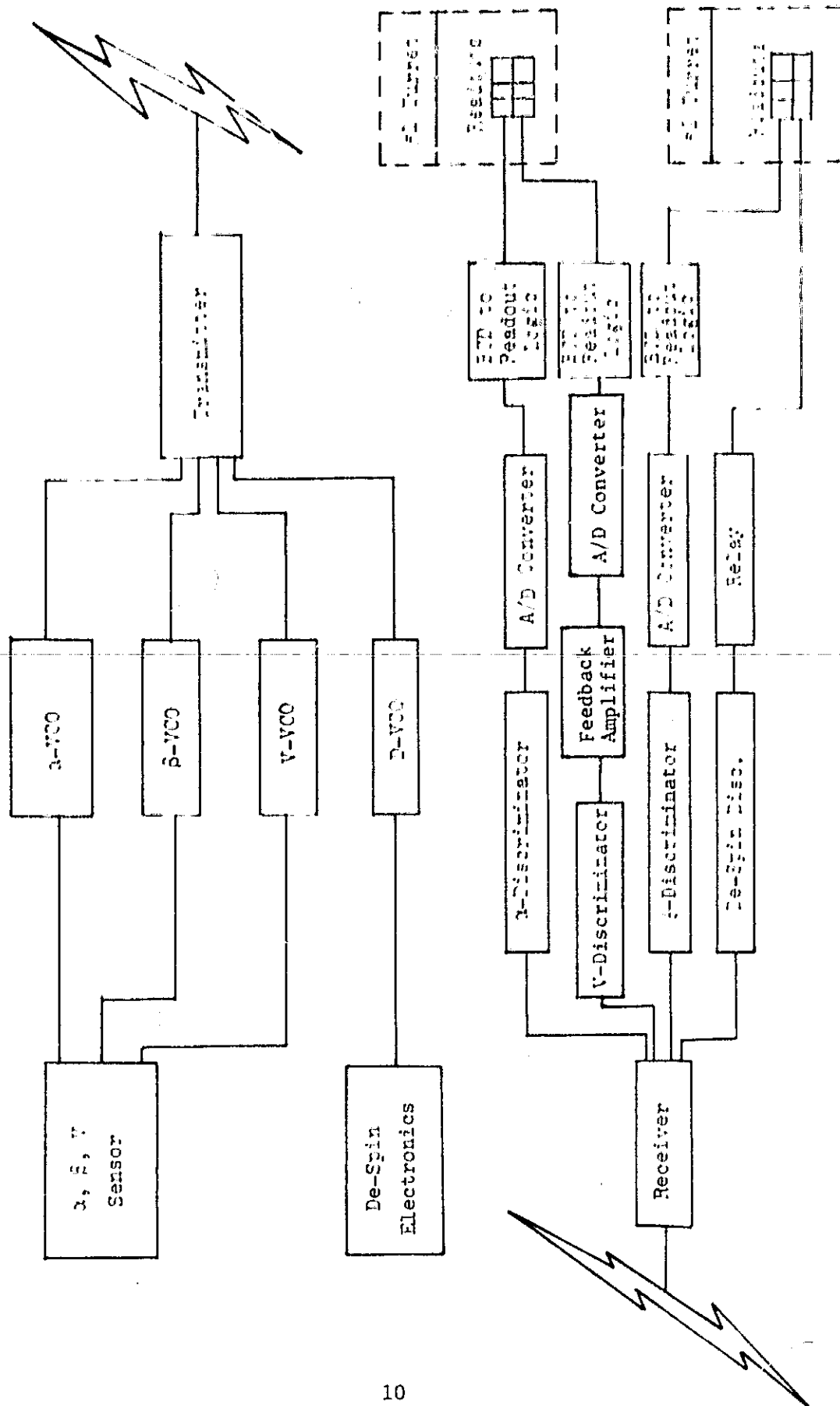


Figure 2 - Simplified Block Diagram Of The Binocular Information Display System

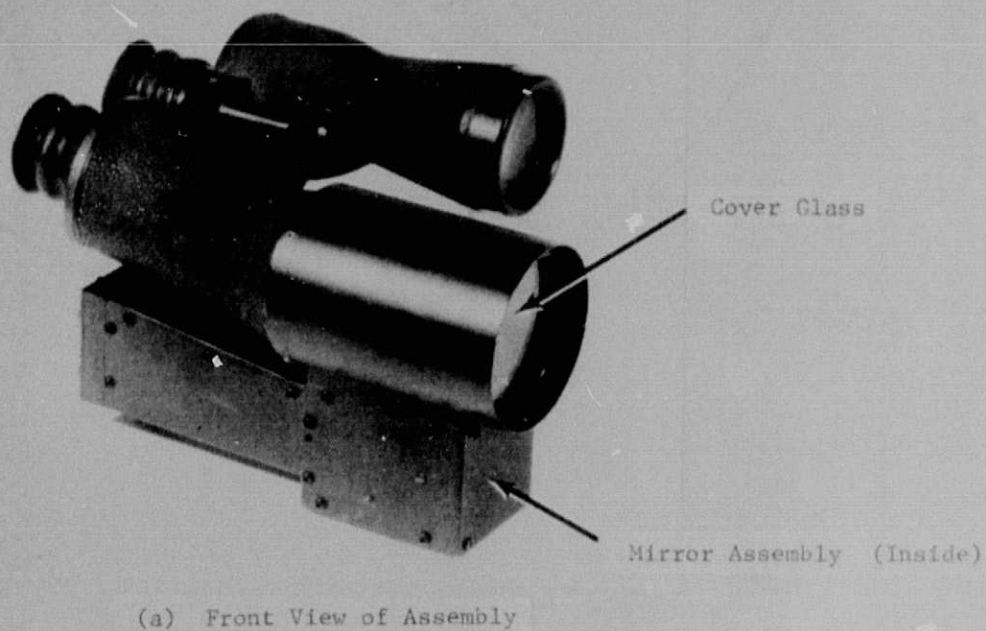
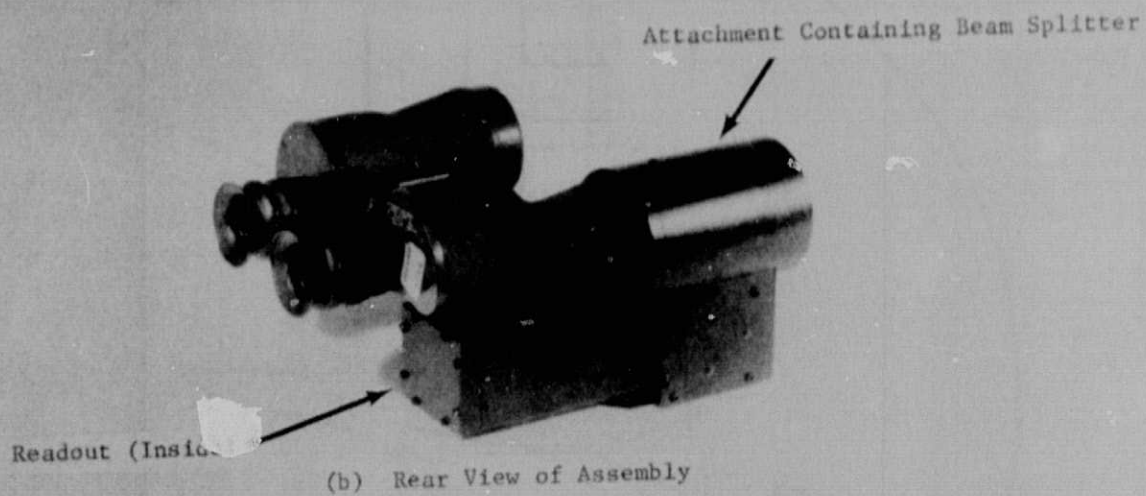


Figure 3 - Binoculars with BID Optical System Attached

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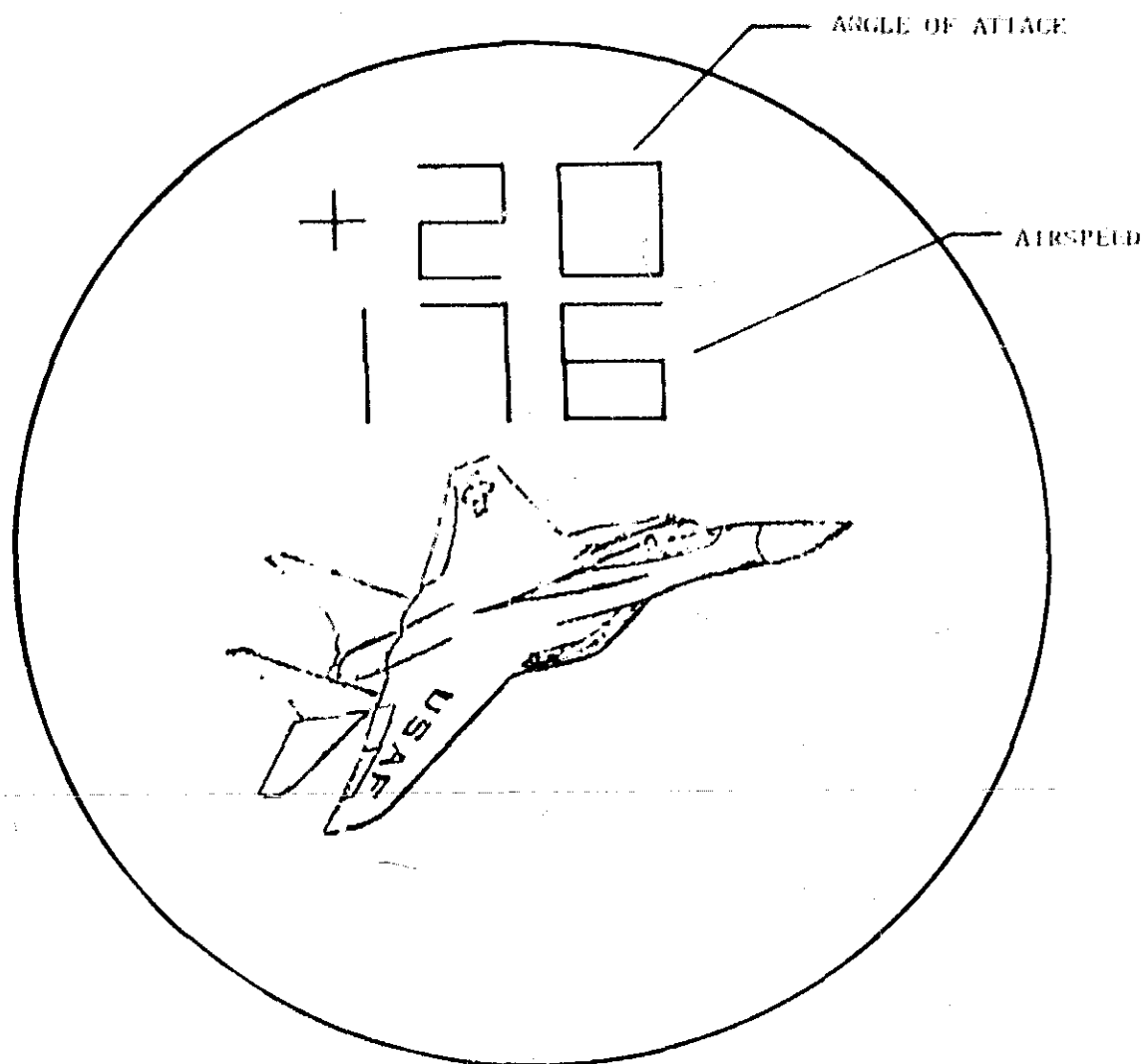


Figure 4 - Information Display As Viewed By A Pilot Through Binoculars



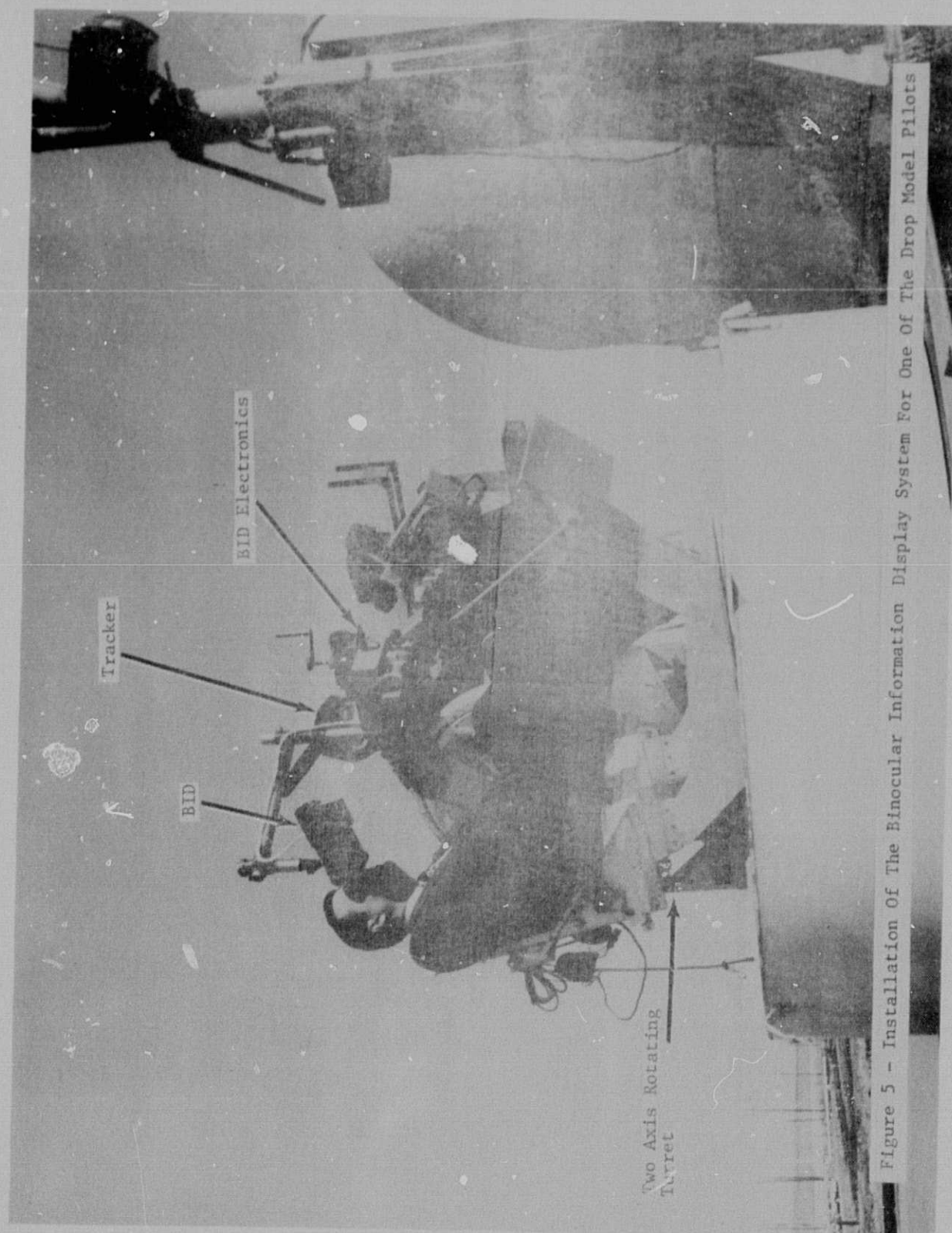


Figure 5 - Installation Of The Binocular Information Display System For One Of The Drop Model Pilots

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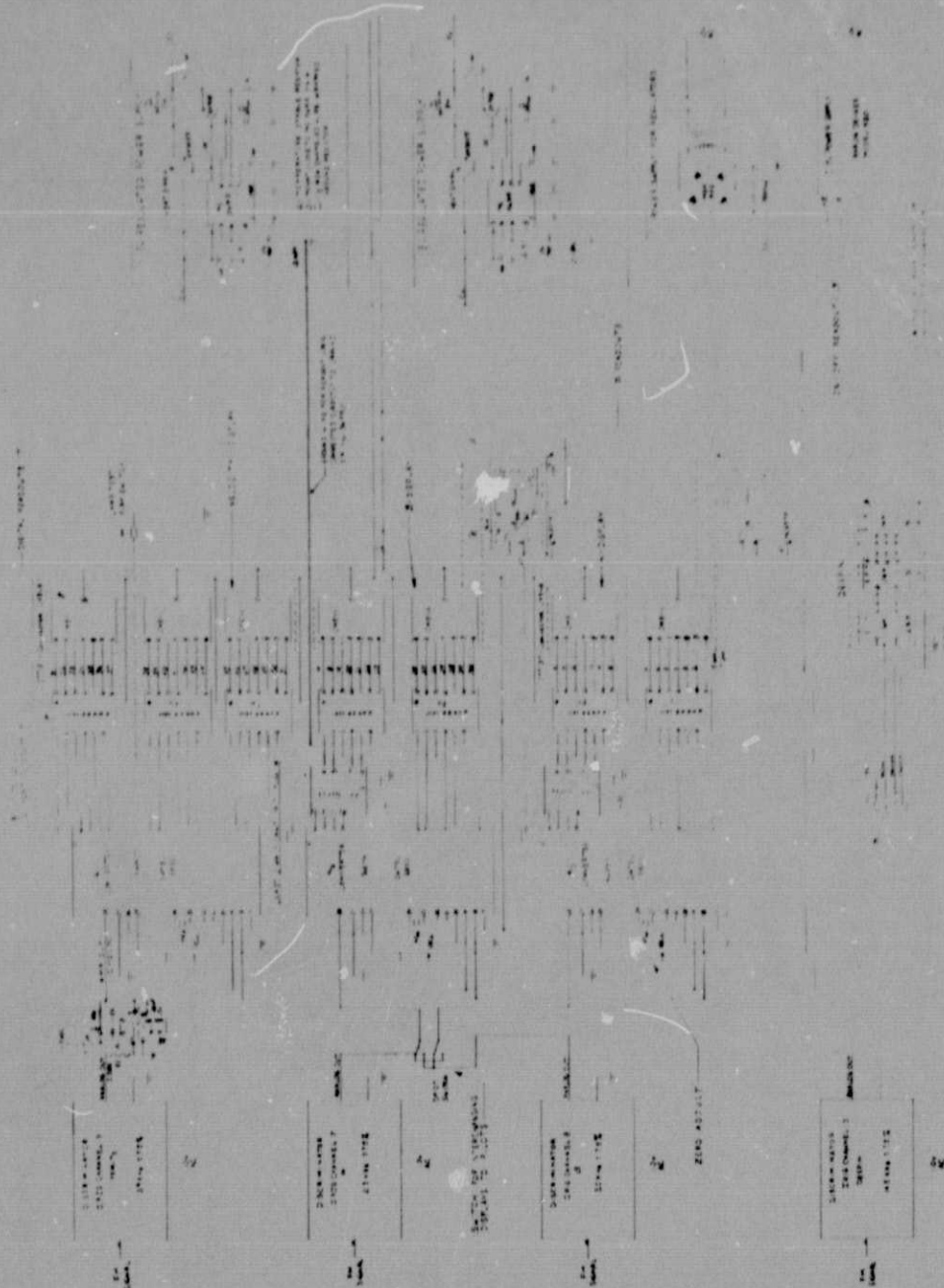


Figure 6 - Schematic Diagram of the BID Electronics System

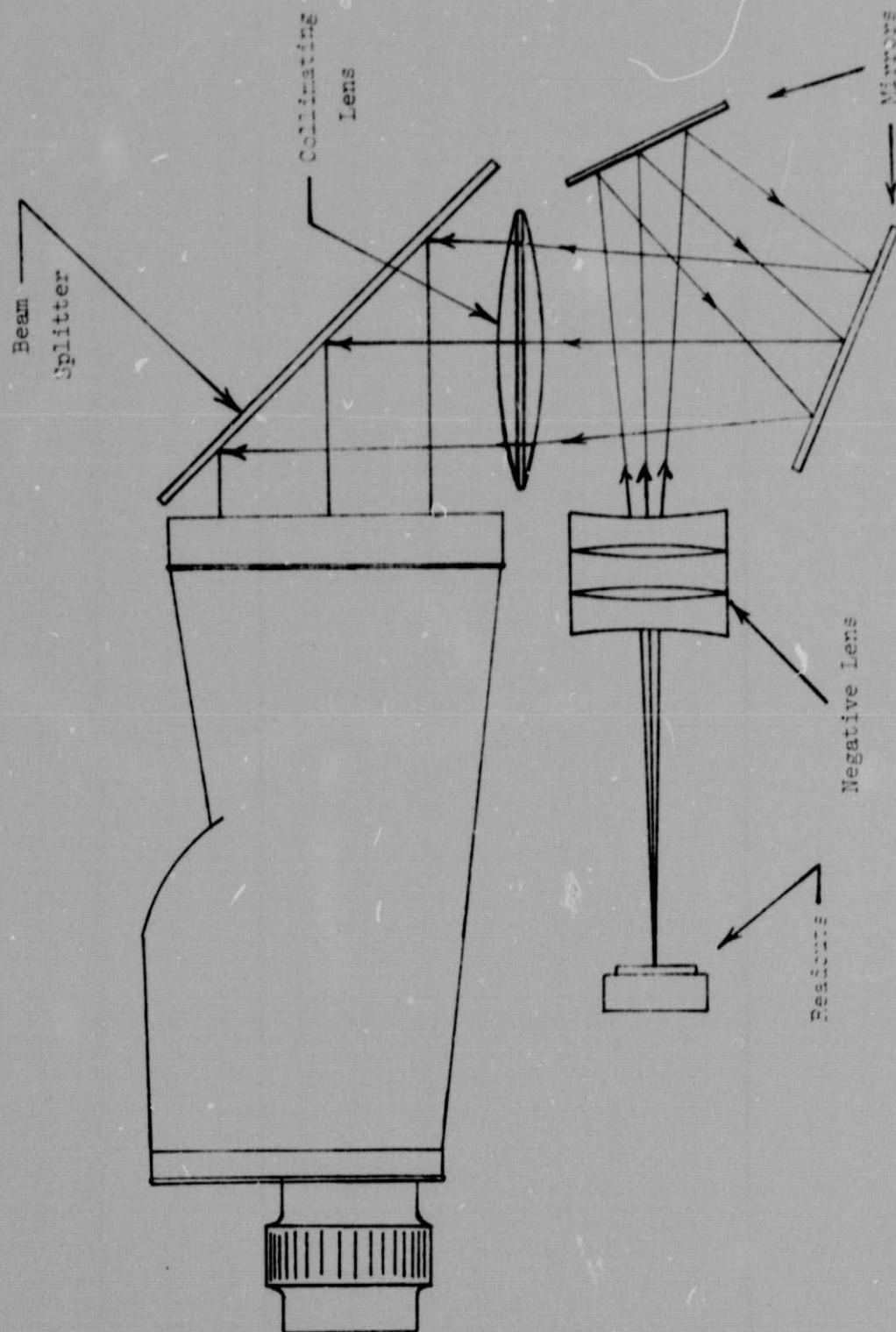


Figure 7 - Schematic Diagram Of The BID Optical System